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UNDER SECTION 77(6) (a)**

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I, ERIC HAROLD HAWKSLEY, M.I.L., M.I.T.I., of 1 Elm Close, Pensby, Wirral, declare that I am conversant with the German and English languages and that to the best of my knowledge and belief the accompanying document is a true translation of the text on which the European Patent Office has granted European Patent No. 098930 in the name of Friedrich Deckel AG..

Signature of Translator 
This 30th day of April 1988

The invention relates to a method of the type set forth in the preamble of claim 1, and to an apparatus for performing this method.

Monitoring of the wear on tools or of the breakage of tools is of great importance especially in modern NC machine tools. In addition to the methods in which the power consumption is measured as an indication of the state of the tool during the action of the tool, the length of drilling tools, or the like, having a small power consumption is measured periodically, especially in the case of smaller drilling tools or the like.

Methods are already known in which the tool is moved for this purpose to special measuring stations where it is then applied to, for example, a reference surface and the position of the toolholder is measured. A disadvantage of this known method resides especially in the fact that the measuring operation reduces the productive time of the machine. Moreover, a measurement taken by contact is very unfavourable, since the tool must be applied extremely slowly to the surface in order to avoid damage to the tool. Hence, this operation requires control measures specially adapted to it. The expenditure on control means and the time involved in the known measuring method are, in any case, so great that direct measurement of the wear before each application of the tool to the workpiece is generally not undertaken.

US-A-4 131 837 describes an apparatus in which the travel of tool carriages and workpiece carriages, and deflection of the tool in action, are measured

and compared with reference values in order to enable detection of a malfunction of the machine or of its components. No provision is made for direct measurement of wear on the cutting edge of the tool during the feeding or retraction of the tool.

The object of the invention is to provide a method of the type set forth in the preamble of claim 1, and apparatus for performing the method which enables a measurement to be taken substantially without reducing the productive time and which is simple with respect to control technology.

In accordance with the invention, this object is achieved by the features set forth in the characterising parts of claim 1 and claim 8 respectively.

The tool passes through the optical measuring device on its path towards or away from the workpiece. The tool must always cover this path which is included in the unavoidable non-productive operating time. The position of the toolholder, generally a spindle head or the like, is measured at the instant at which the tip of the tool passes through a defined measuring plane, and is compared with a desired position for an intact tool. The difference between the actual position and the desired position is indicative of a change in the length of the tool as a result of breakage of the tool or wear on the tool. The degree of wear which can be measured depends upon the accuracy of measurement which can be achieved.

The desired position may be determined by the tool-setter, so that the tool can be measured and compared with the desired state both when the tool is fed towards, and is retracted from, the workpiece. In this way, it is at the same possible to check to some extent whether the correct tool is being fed.

US-A-3 794 314 has already described an apparatus in which the standard signals of a travel control are compared with the signals of an independent travel-measuring system which is a laser interferometer operating on the reflection principle in a known manner. However, in this citation, the tool does not pass through an optical measuring plane for the purpose of measuring the wear on the tool.

In accordance with one embodiment of the invention, the desired position is ascertained on the feed path to the workpiece and is compared with the actual position of the toolholder measured during retraction of the tool. Hence, it is also possible to perform complete monitoring in which, starting from the first application of the newly set tool, a measurement is taken after each application.

In a further embodiment of the invention, measurement is undertaken by means of a light barrier. The tool is passed through the light barrier during feeding and retraction, the interruption and the release of the light beam being evaluated as electrical signals. Preferably, an electronic evaluation unit is provided for this evaluation. A warning signal is produced in the evaluation unit when the actual position of the toolholder differs from the desired position, and,

for example, can lead to a warning indication for switching off the machine or for automatically exchanging the tool for a new tool.

In one embodiment of the invention, the light barrier is fixedly disposed in the machine frame. If further movements in addition to the feed movement are assigned to the tool, care must be taken to ensure that the tool is always guided through light barrier during its travel towards and away from the workpiece.

The method in accordance with the invention is performed by an apparatus in accordance with claim 8. Preferably, the optical measuring device is a laser light barrier which is aligned transversely of the feed path of the tool towards the workpiece. Laser light barriers supply a very sharply focussed light beam, so that high accuracy of measurement can be achieved.

Further advantages and features of the invention are included in the claims, the drawings and the description.

One embodiment of the invention is illustrated in the drawings and is further described hereinafter. In the drawings:

Fig. 1 is a diagrammatic plan view of a machining centre;

Fig. 2 shows a tool carrier with a drilling tool.

The machine tool shown in Fig. 1 includes a machine bed 2 on which a machine column 4 is mounted so as to be feedable horizontally in the direction of the arrow 6. A spindle head 8 is disposed on the machine column 4 so as to be vertically displaceable, and carries a tool 12 in a spindle 10. A workpiece table 18 is clampable to a workpiece table 16 which is mounted on the front of the machine column 2 so as to be displaceable horizontally in the direction of the arrow 14.

The travel of the machine column 4 is measured by means of a scale 20 indicated diagrammatically. By way of example, the position of a plane 22, determined by the spindle 10, relative to the zero point 24 of the scale 20 is measured.

A laser light barrier 26, comprising a transmitter 28 and a sensor 30 which is located opposite to the transmitter, is disposed on the machine column 2 or on components rigidly connected to the machine column. The light barrier is disposed in such a way that the light beam is aligned transversely of the feed direction 6 of the tool 12. When the tool assumes a predetermined vertical position established by the position of the light barrier, the tip of the tool passes through the light barrier during the feed movement and masks the light barrier. This operation can be evaluated as an electrical signal. When the tool is retracted, it unmasks the light beam and this operation can again be evaluated as a signal.

An electronic evaluation unit 32 is provided for evaluating these signals and is electrically connected to the sensor 30.

In order to keep the optical system clean from cooling water, drillings and other contamination, air can be blown onto the transmitter 28 and the sensor 30 through a respective blast nozzle 34 associated with each of these components. Furthermore, the transmitter 28 is also protected by a protective cap 36 which can be swung away during the measuring operation.

Fig. 2 shows a tool carrier 38 with a drilling tool 40 clamped therein. The tool-setter sets the exact dimension x_m from the tip of the tool to a plane 42. The plane 42 coincides with the plane 22 when the tool is inserted into the spindle. C must be equal to x_m if the tool is intact, otherwise the tool is worn or broken.

The apparatus operates as follows:

If the tool is to be changed after use, it is disengaged from the workpiece 18 and is then retracted to the level of the light barrier until it unmasks the laser beam 44. The position of the column 4, indicated by the letter B, is measured at this instant. The dimension C is calculated by the equation $C = A - B$ from the dimension B and the fixed dimension A (the distance between zero point 24 and laser beam 44). If $C > x_m$, the tool is worn or broken and the evaluation unit 32 produces a warning signal which is evaluated in the manner described above.

The tool-setter can input the dimension x_m into the evaluation unit. Alternatively, however, the dimension x_m can be ascertained by the measuring apparatus itself during feeding of the tool. The dimension $x_m = C$ (for the intact tool) then results at the instant at which the tip of the tool interrupts the laser beam, again from the measurement of the dimension B by the equation $C = A - B$.

A change arm 48 is provided in a known manner for changing the tools and takes a new tool from a tool magazine 46 and exchanges it for the worn tool.

Patent Claims

1. A method of measuring the wear on a tool (12) which is received in a toolholder and is movable in a feed direction, the tip of the tool (12) being moved to a reference position in a reference plane and the position of the toolholder is then measured and is compared with a desired position which corresponds to the position of the toolholder when the non-worn tip is in register with the reference position (44), characterised in that, during travel of the tool (12) towards the workpiece (18) and/or during travel away from the workpiece (18), the tip of the tool passes through an optical measuring device (28, 30) having an optical measuring plane (44) which extends approximately transversely of the path of the tool and which serves as a reference position and detects the passage of the tip.
2. A method as claimed in claim 1, characterised in that the actual position corresponding to the passage of the tip is compared with a desired position ascertained outside the measuring device (28, 30).
3. A method as claimed in claim 1, characterised in that the desired position is ascertained on the feed path towards the workpiece (18) and is compared with the actual position measured during retraction from the workpiece (18).
4. A method as claimed in any one of claims 1 to 3, characterised in that the actual position and

desired position of the toolholder (4) are measured at the instant at which the tip of the tool passes through a light barrier (44).

5. A method as claimed in any one of claims 1 to 4, characterised in that the actual position and the desired position of the toolholder (4) are represented as electrical signals and are evaluated in an electronic evaluation unit (32).
6. A method as claimed in claim 5, characterised in that a warning signal or the like is produced in the evaluation unit (32) in the event of differences between the desired and actual positions of the toolholder (4).
7. A method as claimed in any one of claims 4 to 6, characterised in that the light barrier (44) is fixedly disposed in the machine tool and that the tool (12) is always conducted through the light barrier on its path to and from the workpiece (18).
8. An apparatus for performing the method claimed in claim 1, comprising a toolholder (4), movable in a feed direction, for holding a tool (12), a defined reference position in a reference plane (44) to which the tip of the tool (12) can be applied, and a position-measuring device (20, 22) for measuring the position of the toolholder, characterised in that the reference plane (44) serving as a reference position is defined by an optical measuring device (28, 30) which is located in the feed and return path of the tool (12) and approximately transversely of

the forward and return direction, and an evaluation device (32) is connected to the optical measuring device (28, 30).

9. An apparatus as claimed in claim 8, characterised in that the optical measuring device (28, 30) is a light barrier or the like.
10. An apparatus as claimed in any one of claims 8 or 9, characterised in that the optical measuring device is formed by a laser light barrier which comprises a transmitter (28) and a sensor (30) and which is aligned transversely of the direction of the tool (12) on its feed path towards the workpiece (18) or away from the workpiece (18).
11. An apparatus as claimed in any one of claims 8 to 10, characterised in that an electronic evaluation unit (32) is provided for the evaluation of the signals of the optical measuring device (28, 30) and for producing a warning signal in the event of a difference between the desired position and the actual position of the toolholder (4).
12. An apparatus as claimed in any one of claims 10 or 11, characterised in that a masking flap (36) or the like, controllable by the evaluation unit (32), is provided for the transmitter (28) of the laser light barrier.
13. An apparatus as claimed in any one of claims 10 to 12, characterised in that blast nozzles (34) or the like are provided for keeping the

transmitter (28) and the sensor (30) of the
laser light barrier clean.

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FIG.1

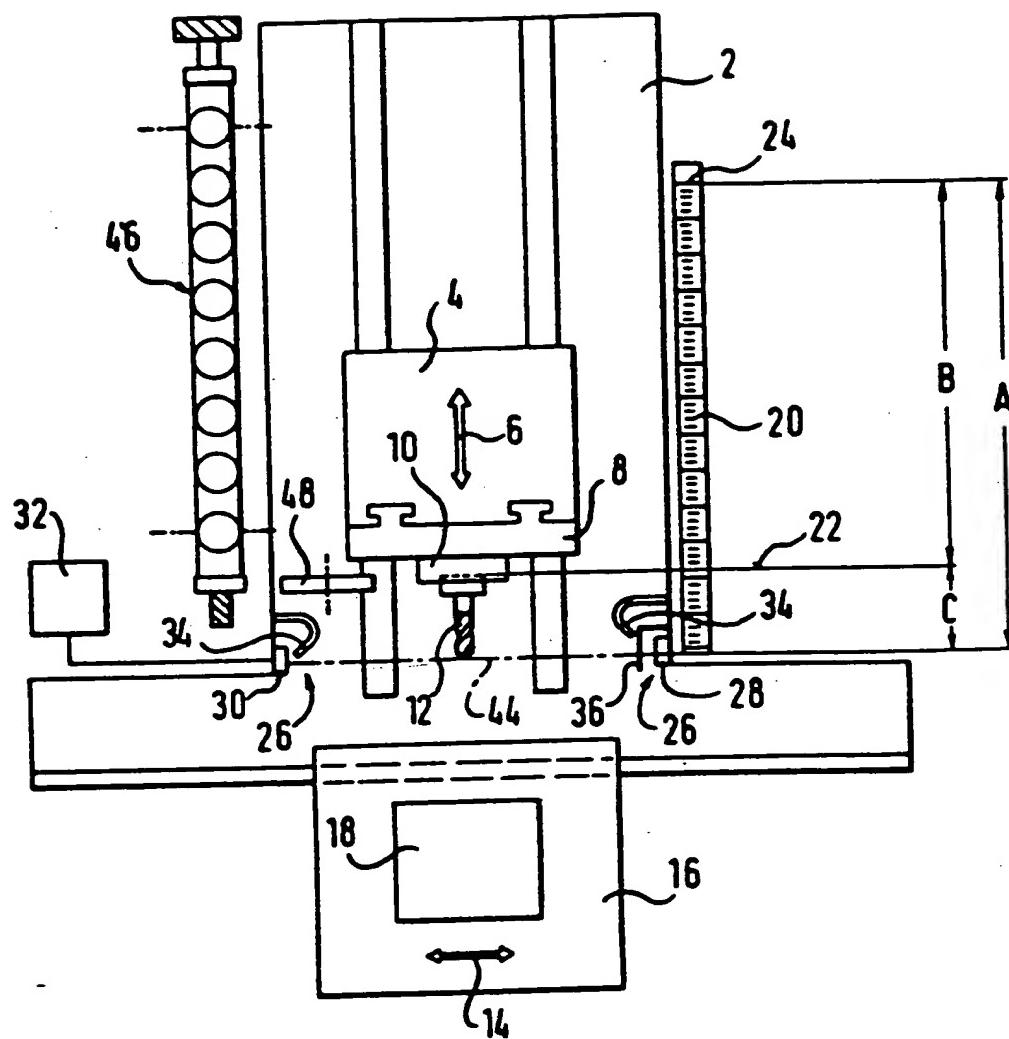
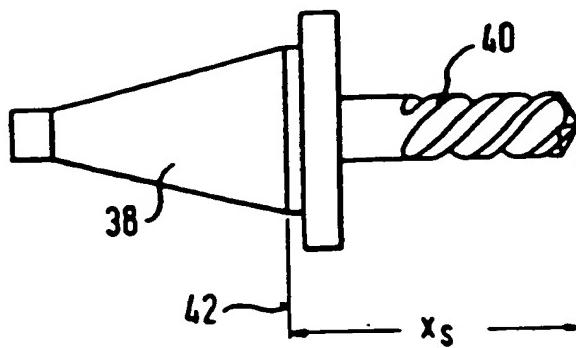


FIG.2



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